Julius Kühn-Institut
Bundesforschungsinstitut für Kulturpflanzen
Federal Research Centre for Cultivated Plants

Recent progress in grapevine breeding

Rudolf Eibach

Institute for Grapevine Breeding Geilweilerhof

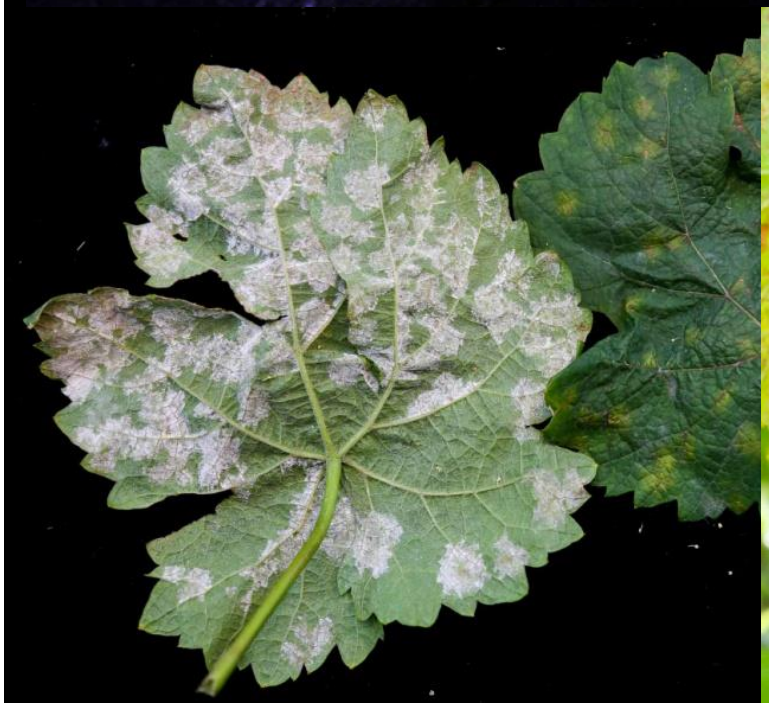
Topics:

1. Breeding for mildew resistance – stacking resistance genes

2. Introgressing phylloxera resistance

3. High throughput phenotyping

Downy mildew disease incidence in Germany in 2016



Downy mildew disease incidence in Germany in 2016

Scheme of resistance breeding

Vitis vinifera

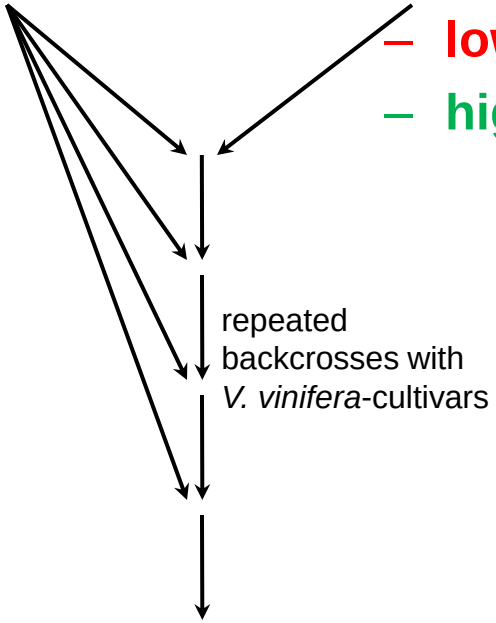
- **high quality**
- **low resistance**

`Müller-Thurgau´

Vitis wild species

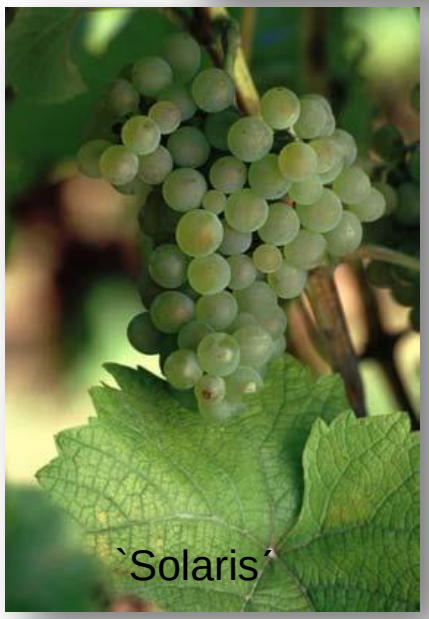
- **low quality**
- **high resistance**

Vitis amurensis



new cultivar

- **high quality**
- **high resistance**



`Solaris´

resistance breeding in Germany

… development of cultivars

1925 — onset of resistance breeding

1950 — Aris, Siegfriedrebe

1990 — Phoenix

Orion, Staufer

Sirius, Merzling, Regent

2000 — Hibernal, Rondo, Prinzipal, Bronner

Johanniter

Saphira, Solaris

Helios

Cab.Carbon, Cab.Carol, Cab.Cortis,

Prior, Monarch, Bolero

2010 — Allegro

Accent, Piroso

Villaris, Reberger, Calandro

Baron

Muscaris, Souvignier gris,

Pinotin

acceptance for producing quality wine

… development of breeding knowledge

1900 — rediscovery of Mendelian rules

1925

1950 — DeLatin: description of trait heritability

1990 — availability of PCR-techniques

2000 — genetic fingerprinting for variety identification

application of marker assisted selection (MAS)

sequencing grapevine genome

2010 — application of high throughput techniques (genotype, phenotype)

resistance breeding in Germany

… development of cultivars

1925 — onset of resistance breeding

1950 — Aris, Siegfriedrebe

1990 — Phoenix

Orion, Staufer

1995 — Regent, Sirius, Merzling

Hibernal, Rondo, Prinzipal, Bronner

2000 — Johanniter

Saphira, Solaris

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C.Carbon, C.Carol, C.Cortis, Prior, Monarch, Bolero

Allegro

2010 — Accent, Piroso

Villaris, Reberger, Calandro

Baron

Muscaris, Souvignier gris,

Pinotin, Cabernet blanc

2015

2020

… identification of resistance loci

Downy Mildew

2000 — Rpv1

2005 — Rpv2

Rpv3.1, Rpv4

Rpv5, Rpv6, Rpv7

2010 — Rpv8, Rpv9, Rpv11,Rpv13

Rpv10,Rpv3.2

Rpv12

2015 — Rpv14

Rpv15 (in preparation)

2020

Powdery Mildew

2000 — Ren2

2005 — Run1

Ren3

Ren1

2010 — Run2.1, Run2.2

Ren4, Ren5

2015 — Ren6, Ren7, Ren8

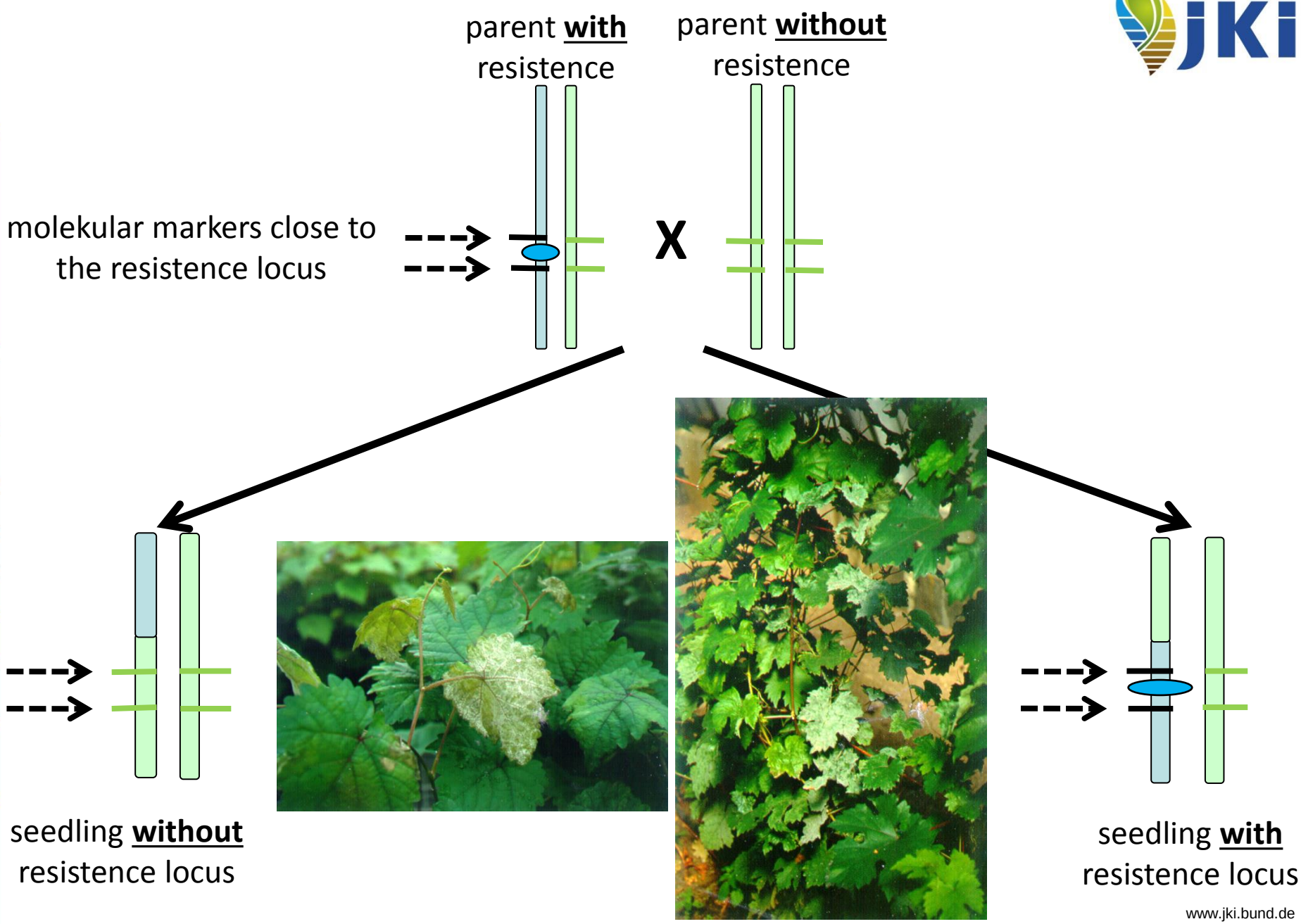
Ren9 (in preparation)

2020

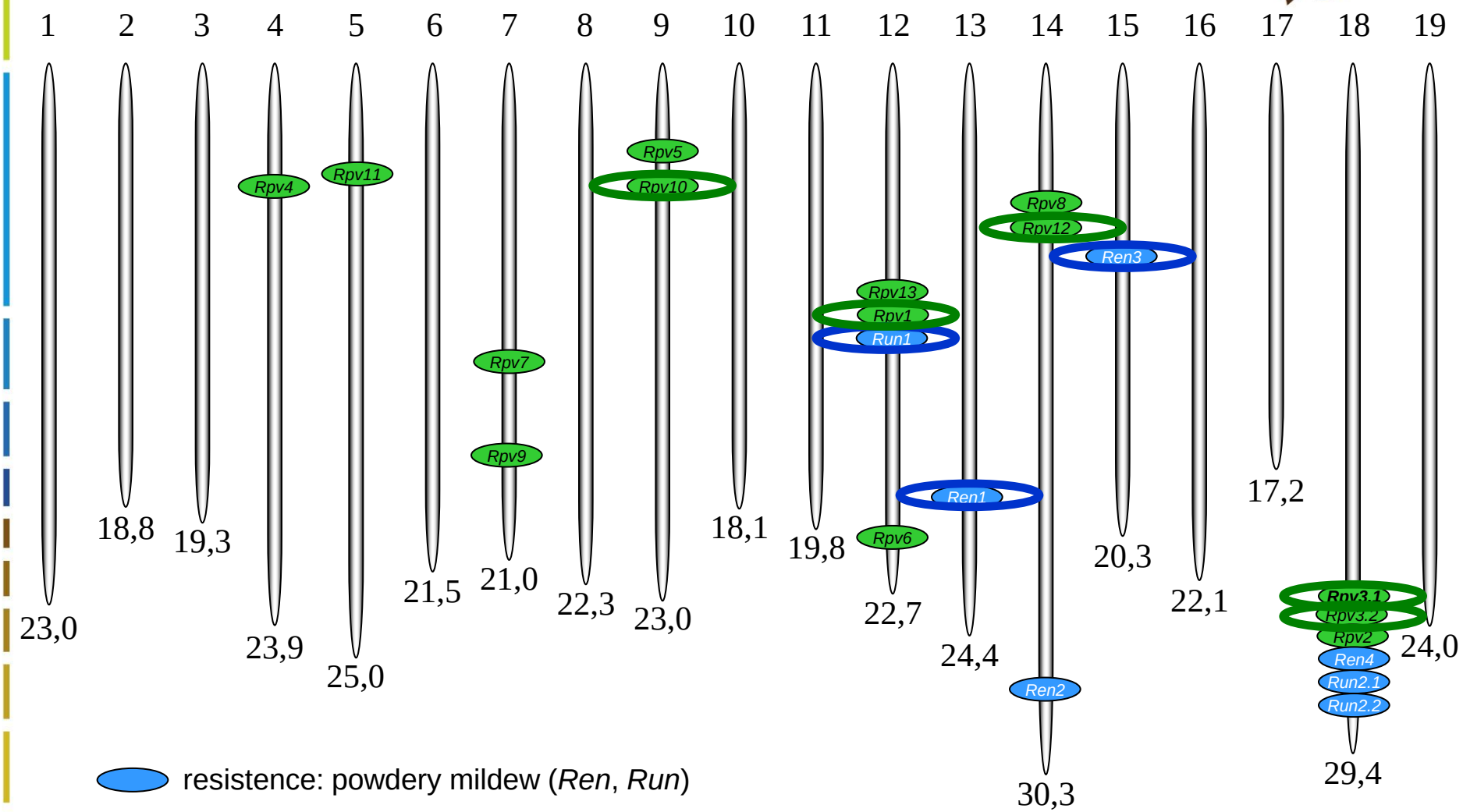
New tool for supporting resistance breeding:

marker assisted selection (MAS)

traditional selection vs. marker assisted selection



identified mildew resistance loci in *Vitis*



resistence: powdery mildew (*Ren*, *Run*)

resistence: downy mildew (*Rpv*)

Breeding strategy:

- stacking resistance loci

Hypothesis:

- increasing degree of resistance
- increasing sustainability of resistance

Material und Methods:

1. **choice of crossing populations with potential for stacking resistance loci**

2. **Marker assisted selection (MAS) for grouping the progeny according to different loci combinations**

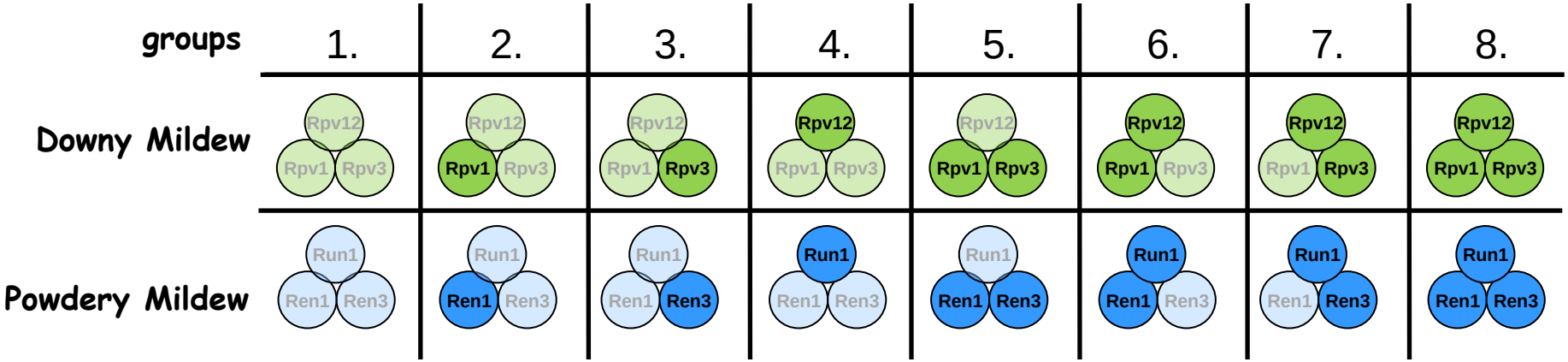
3. **Determination of resistance:**

   - **Downy Mildew**: artificial inokulation of leaf disks and whole plants
   - **Powdery Mildew**: natural infection in greenhouses with high infection pressure

   - rating of resistance from 1 to 9 (1= heavy infection; 9=no infection)

Material und Methods:

1. **marker assisted selection (MAS):**



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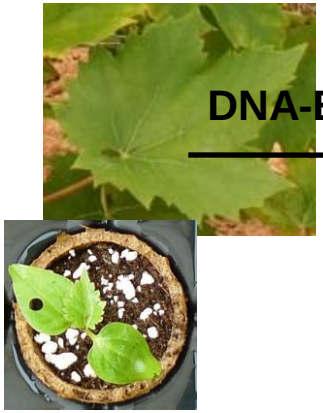
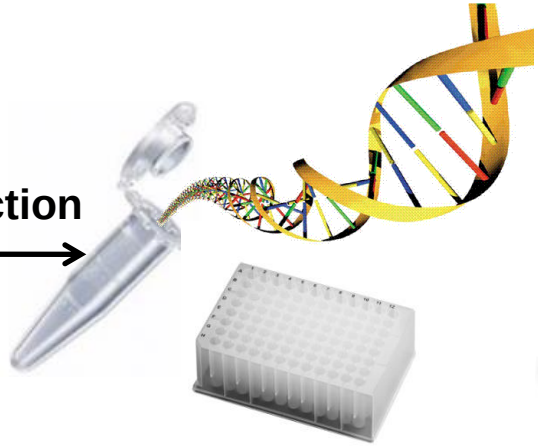
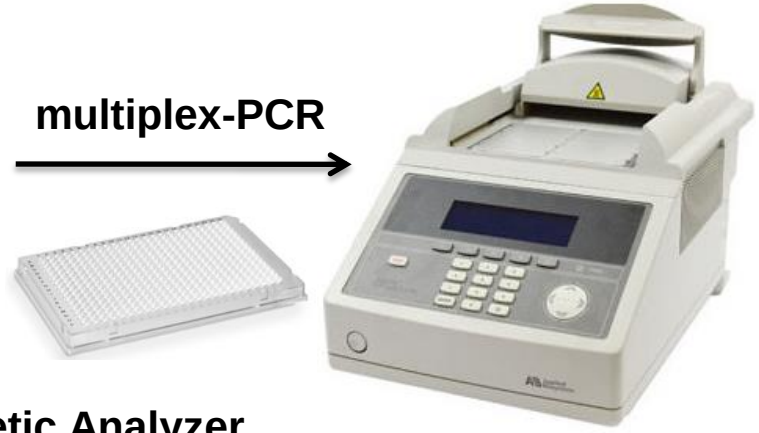
procedure of marker assisted selection



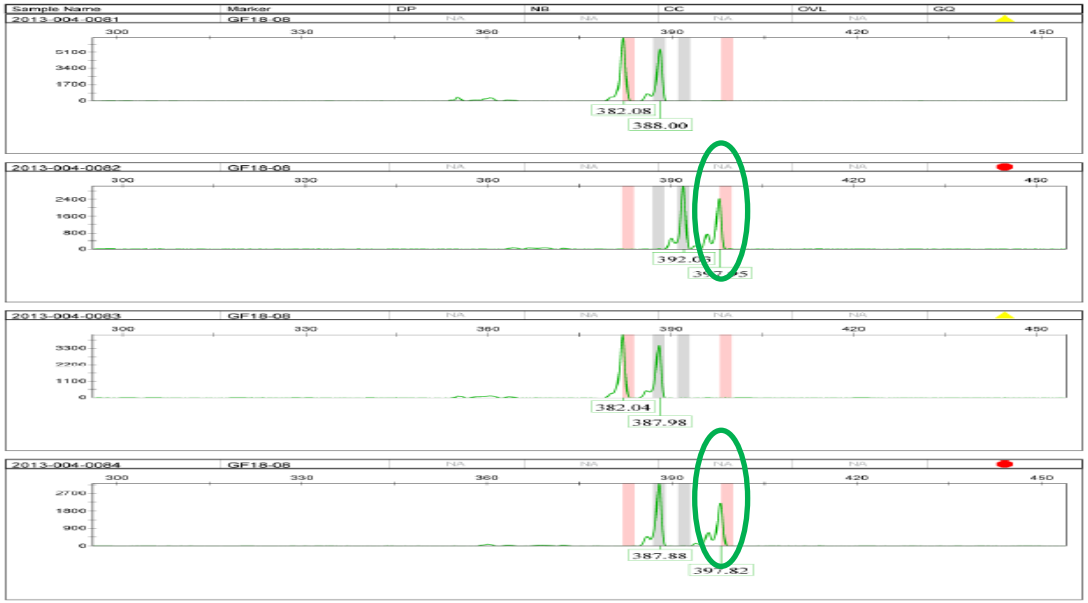
DNA-Extraction →



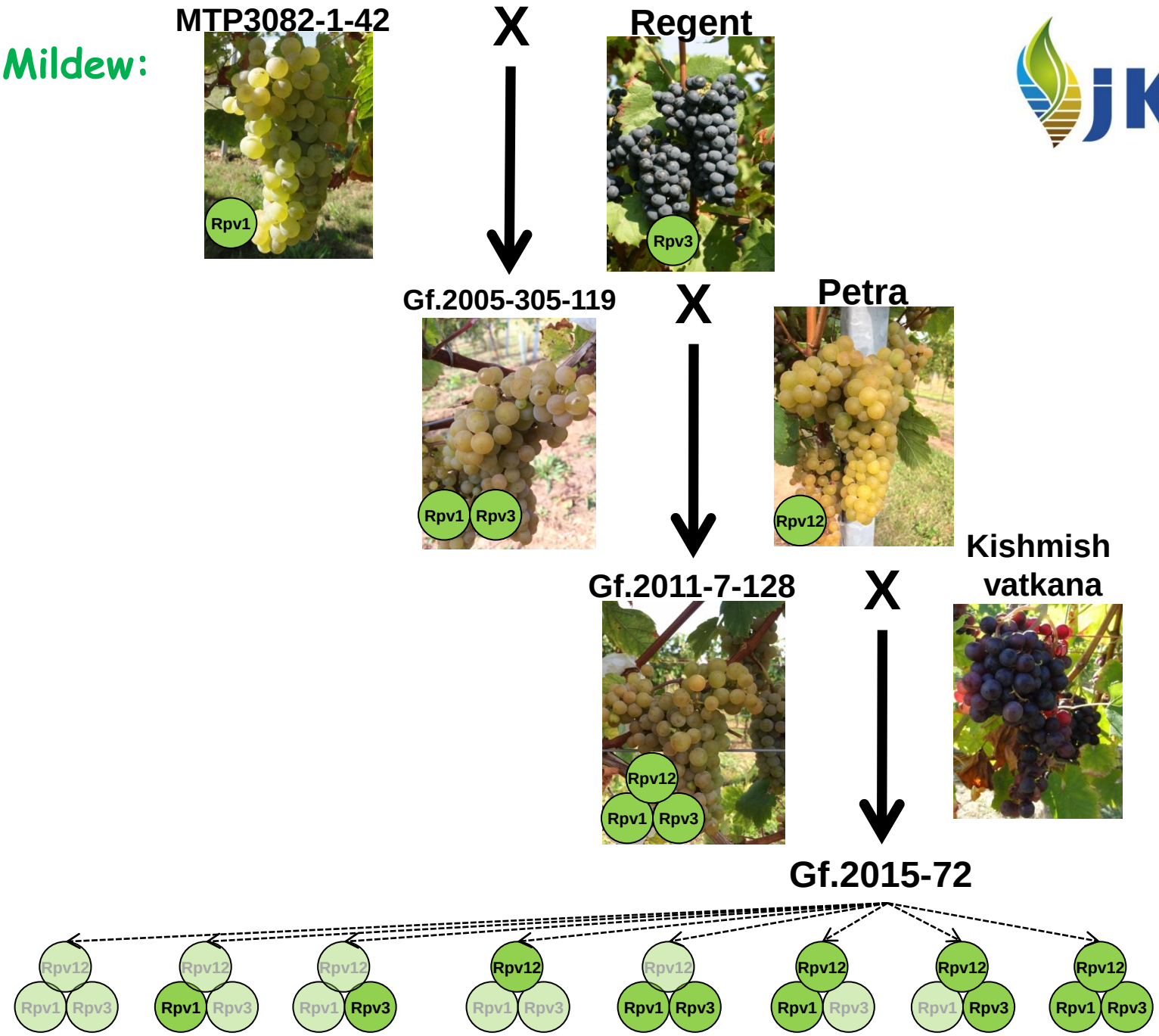
multiplex-PCR →



Fragment Analysis on Genetic Analyzer

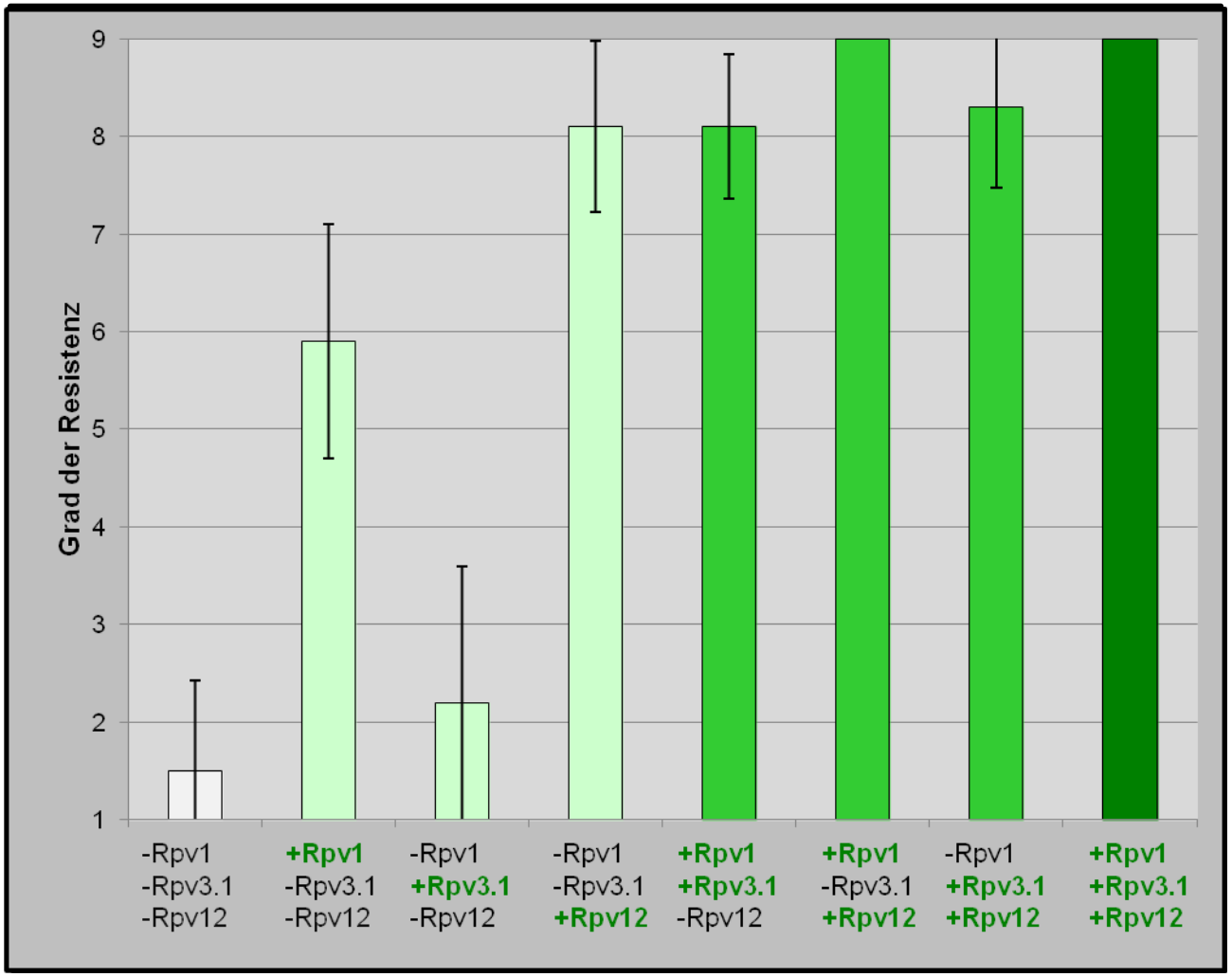


Downy Mildew:



Downy Mildew

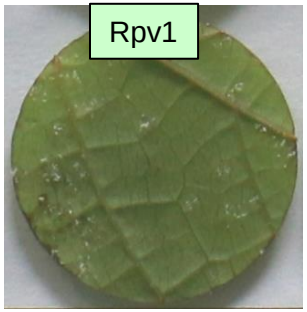
Influence of individual resistance loci and their different combinations on degree of resistance

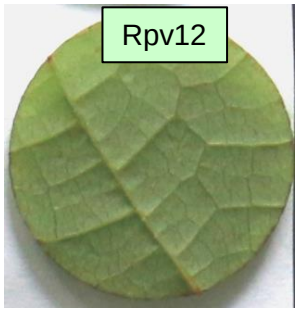


Downy Mildew

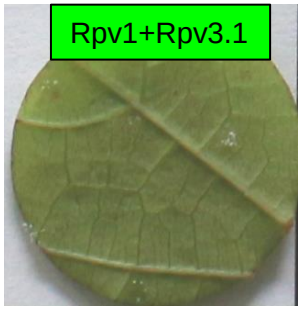
Leaf disc essays

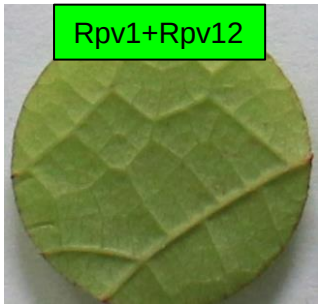
no resistance locus





1 resistance locus





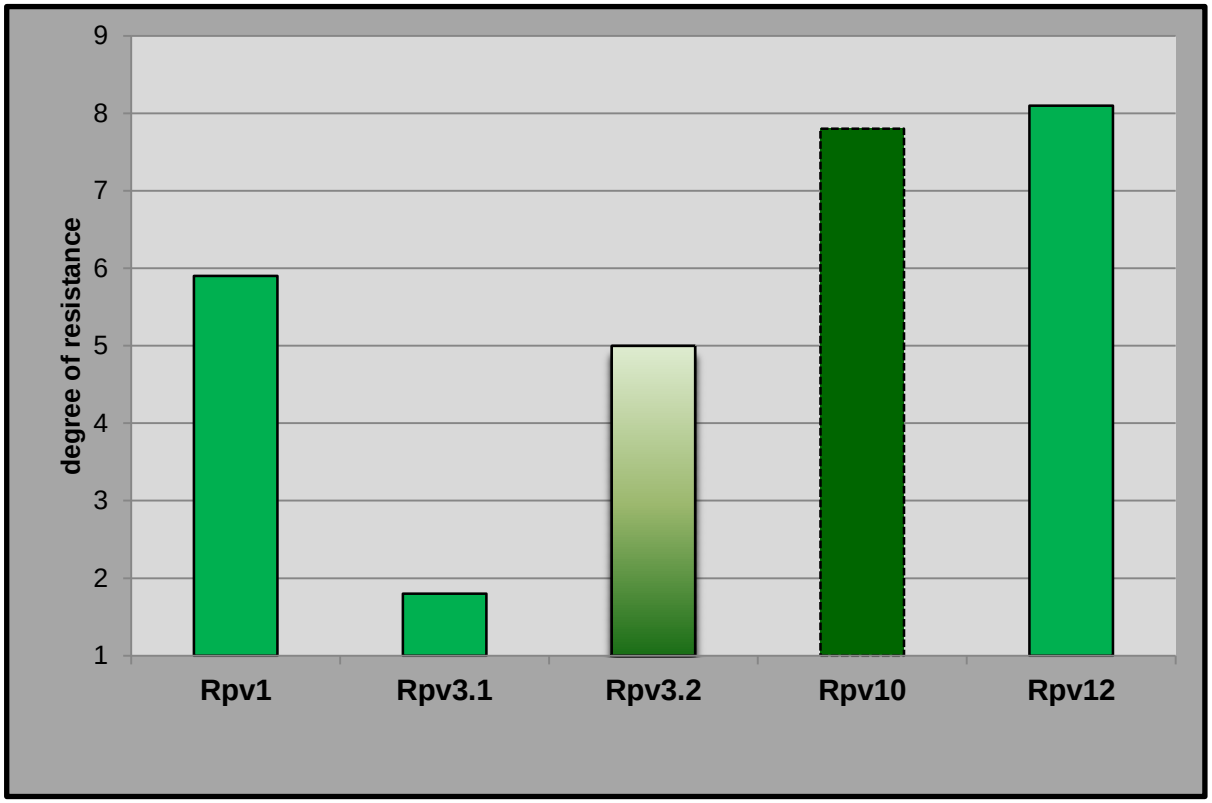
2 resistance loci

Rpv1+Rpv3.1+Rpv12

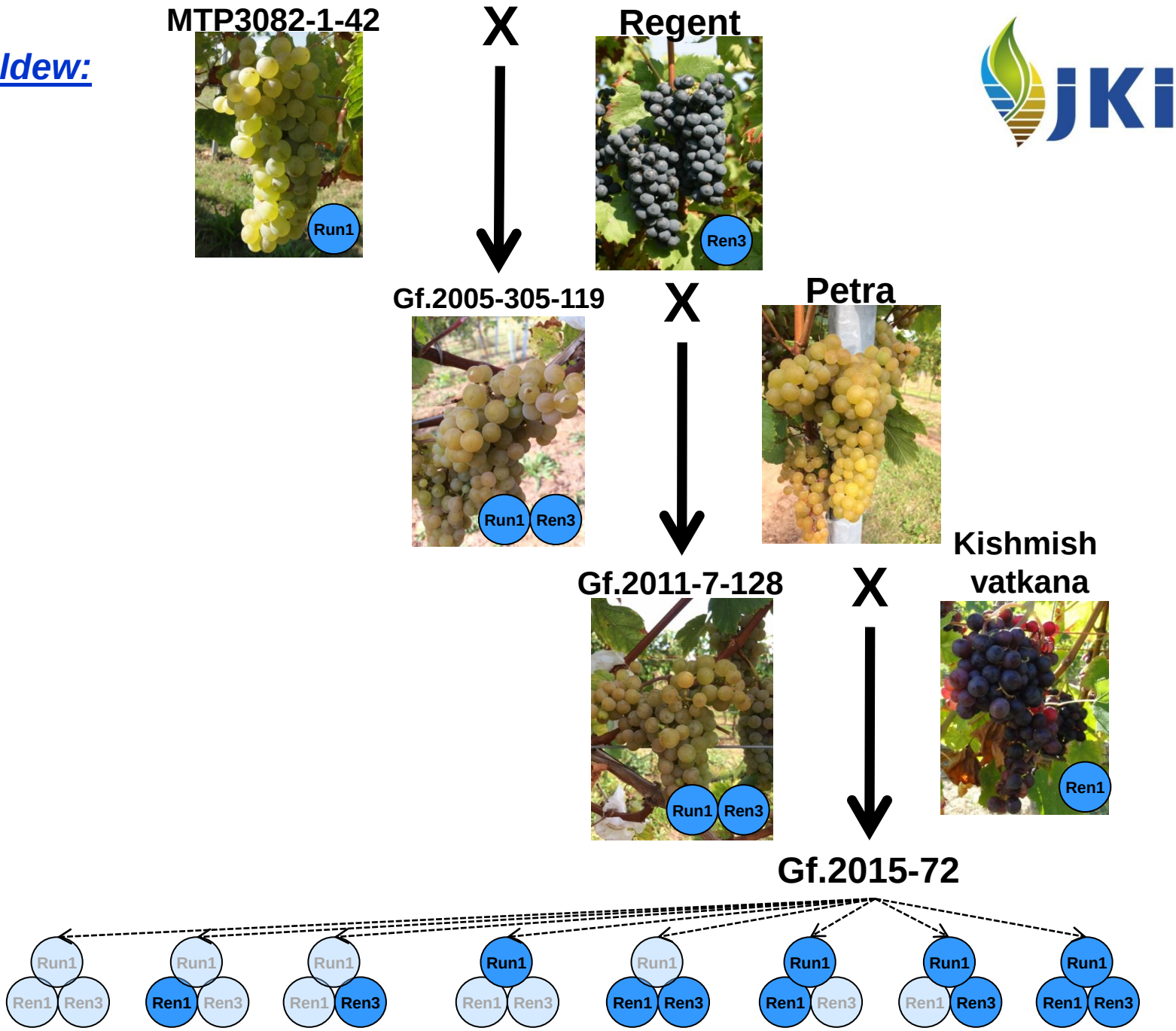
3 resistance loci

Comparison of different Downy Mildew resistance loci for their individual degree of resistance

- Results deduced from different experiments -

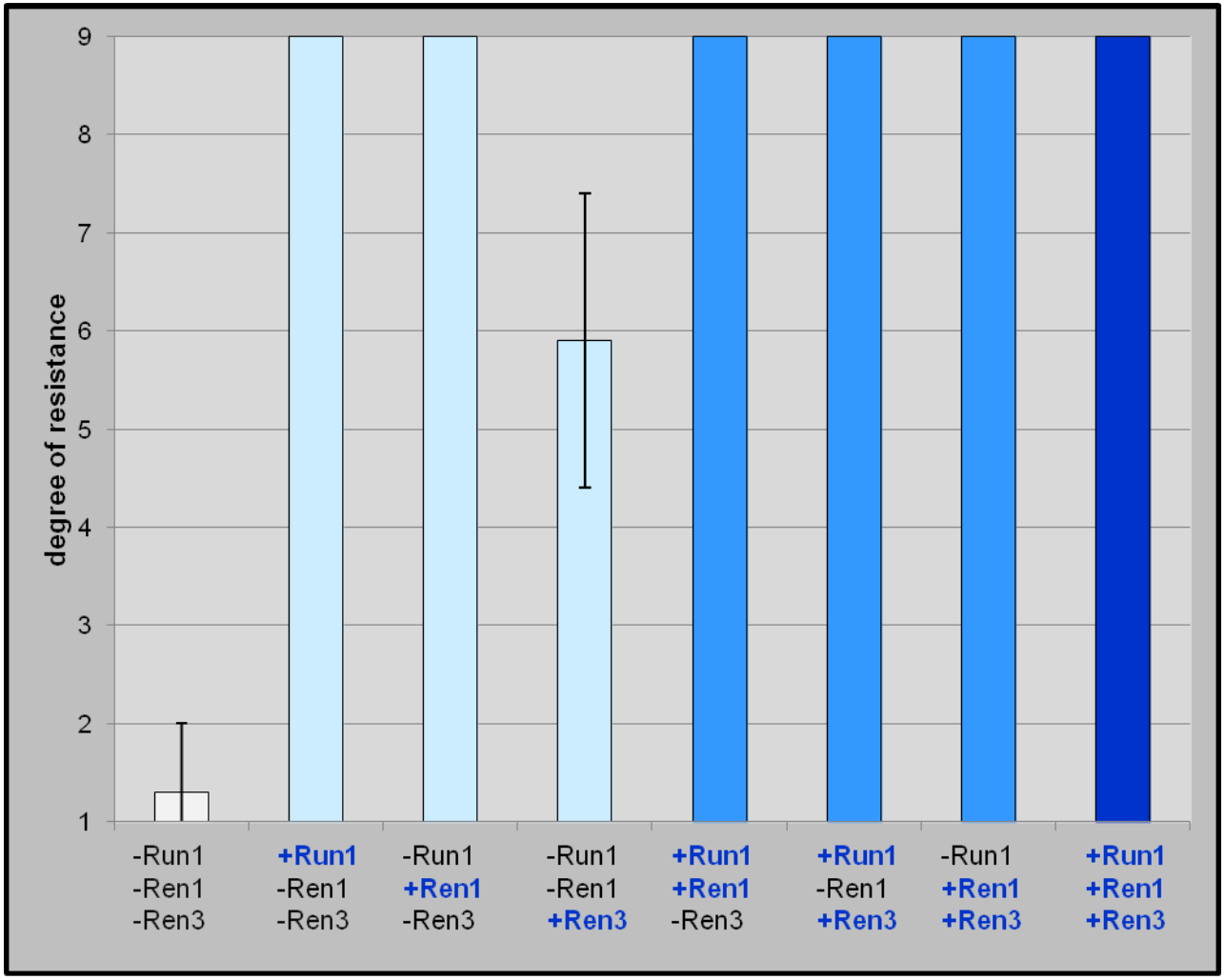


Powdery Mildew:

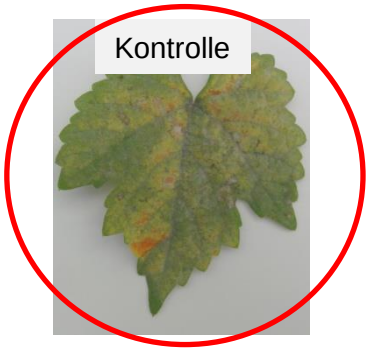


Powdery Mildew

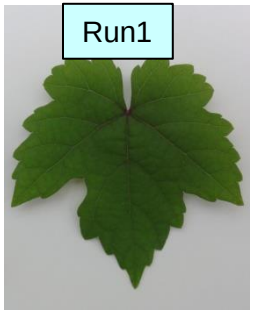
Influence of individual resistance loci and their different combinations on degree of resistance

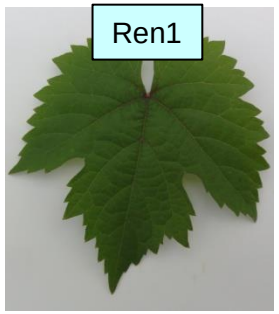


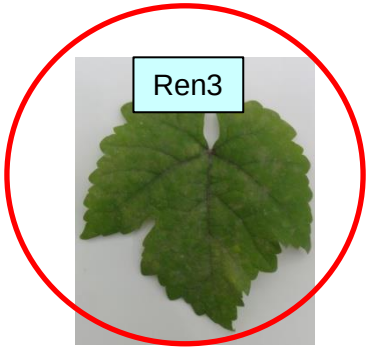
Powdery Mildew:
Example II



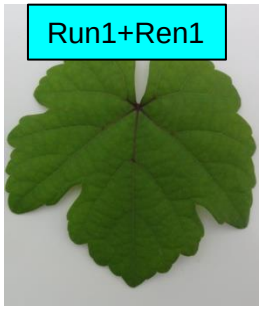
no resistance locus

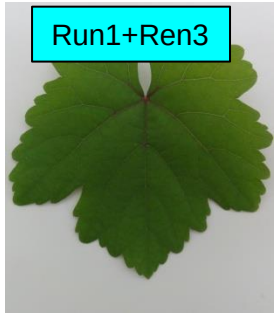


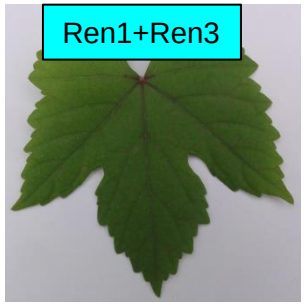




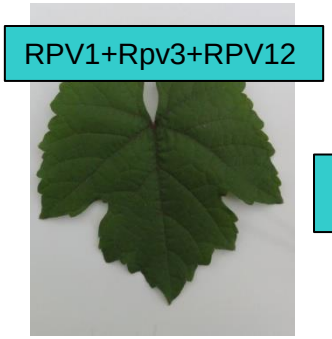
1 resistance locus





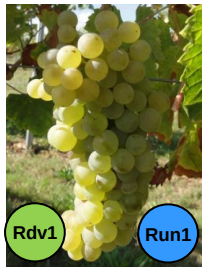


2 resistance loci



3 resistance loci

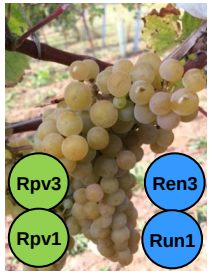
MTP3082-1-42



X

Regent

Gf.2005-305-119

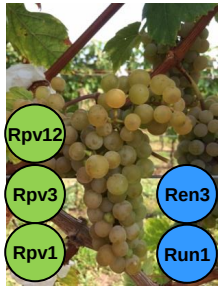


X

Petra

selection for breeding purposes:

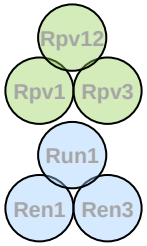
Gf.2011-7-128



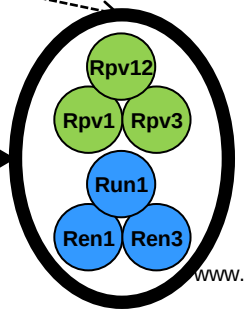
X

Kishmish vatkana

Gf.2015-72



64 different combinations



Calardis blanc (GF.93-22-6)

parentage: **GF. GA-47-42** (Bacchus x Seyval) **x Seyve Villard 39-639**

history

1993: crossing

2000: selection

2001: transfer to pretesting phase

2006: transfer to intermediate testing phase

2009: transfer to main testing phase

cultivar description

degree of resistance:

Powdery mildew: medium -high
Downy mildew: high
Botrytis: medium-high
Black rot: high

viticultural characteristics:

Bud burst: comparable to Riesling
Ripening time: some days before Riesling
growth: upright, marginal formation of axillary shoots
cluster: medium sized, cluster and berry size similar to Riesling, loose cluster

wine characteristic:

Wines are fullbodied and exhibit in general a delicate aroma with a tender spicy flavour. They are characterized by a tangy and mature acid mouth feeling.

Calardis blanc (GF.93-22-6)

parentage: **GF. GA-47-42** (Bacchus x Seyval) **x Seyve Villard 39-639**

performance characteristics

Mean values from 2003 – 2012

yield

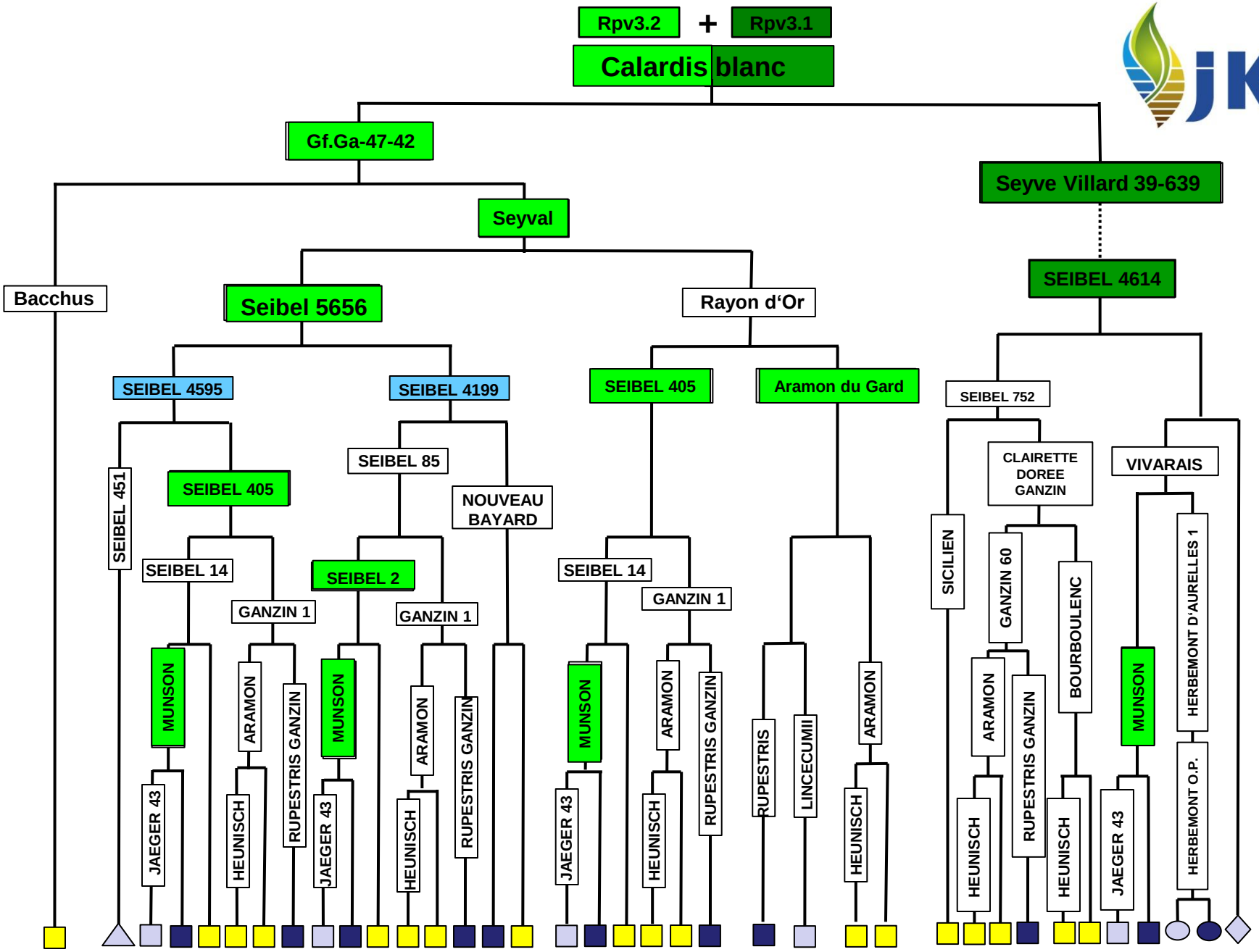
	kg/ar	%
Müller-Thurgau	141	100
Calardis blanc	124	88

sugar content

	°Oechsle	%
Müller-Thurgau	75	100
Calardis blanc	83	112

acid content

	g/l	%
Müller-Thurgau	7,0	100
Calardis blanc	7,1	100



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Topics:

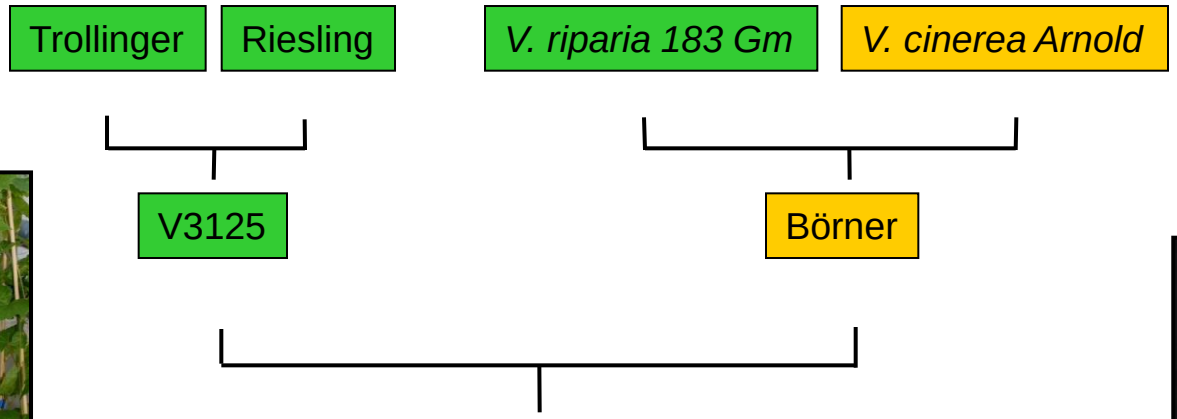
1. Breeding for mildew resistance – stacking resistance genes

2. **Introgressing phylloxera resistance**

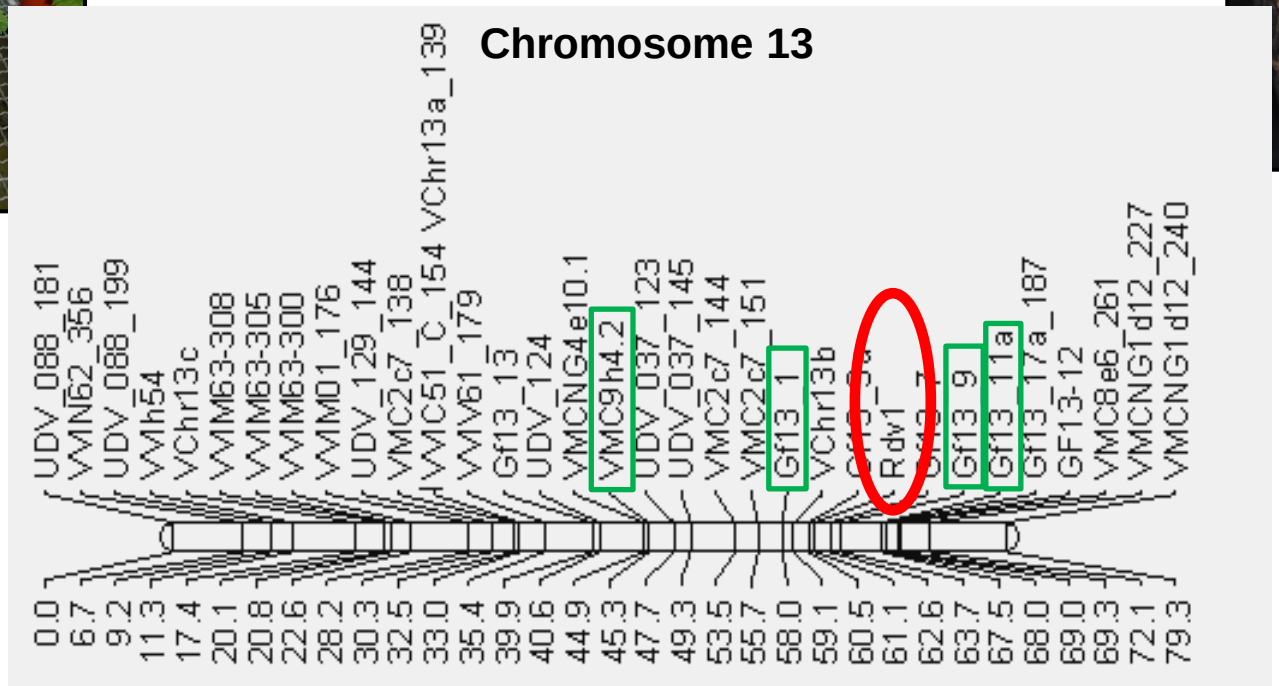
3. High throughput phenotyping

Introgression of resistance against phylloxera on roots into the genepool of *Vitis vinifera*

Crossing scheme

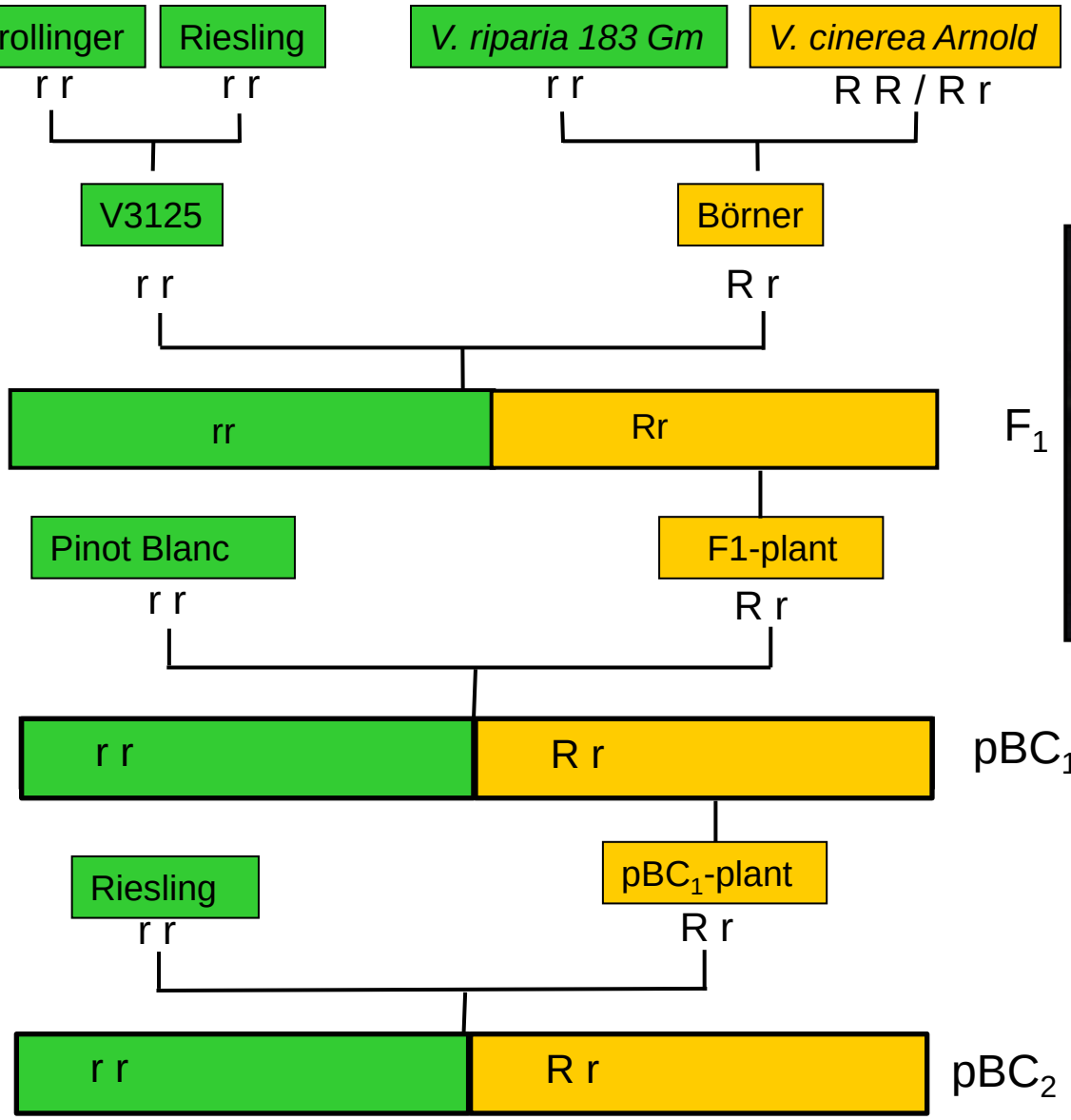


F_1



Introgression of resistance against phylloxera on roots into the genepool of *Vitis vinifera*

Crossing scheme



Introgression of phylloxera resistance in genepool of Vitis vinifera

Gf.V3125
(Trollinger x Riesling)

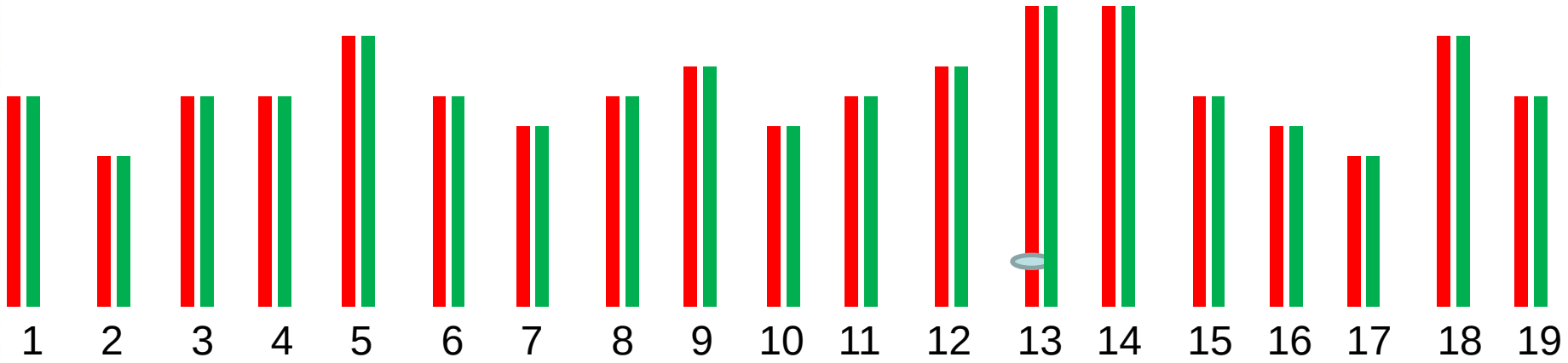
X

Börner

↓

Gf.1998-42-109

F_1-generation



green: Vinifera **red: wild species** **Rdv1: locus for phylloxera resistance**

Introgression of phylloxera resistance in genepool of Vitis vinifera

Gf.V3125 (Trollinger x Riesling) X Börner

↓

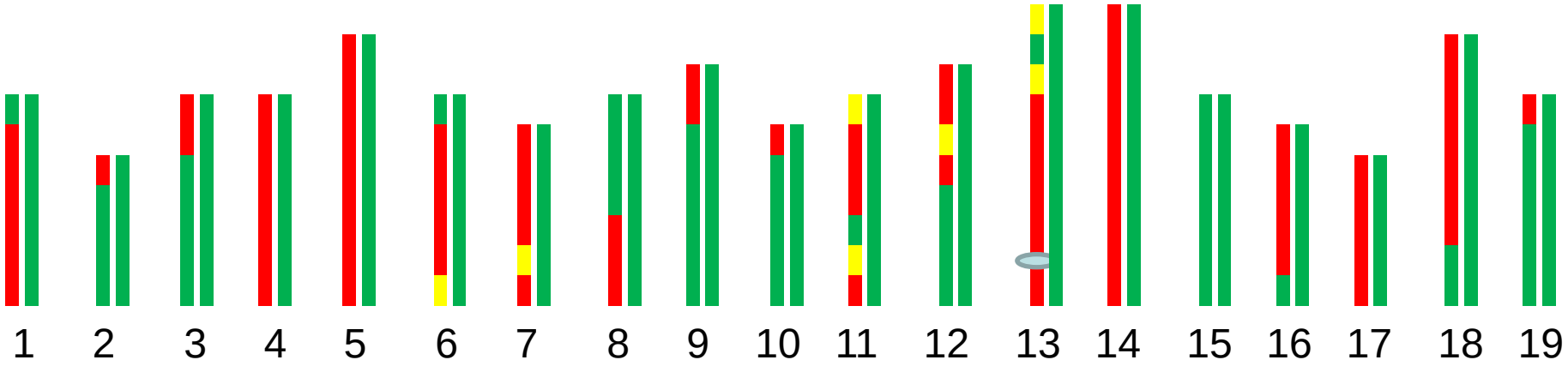
F_1-generation

Pinot blanc X Gf.1998-42-109

↓

pBC_1-Generation

Gf.2008-83-173



green: Vinifera **red: wild species** **Rdv1: locus for phylloxera resistance**

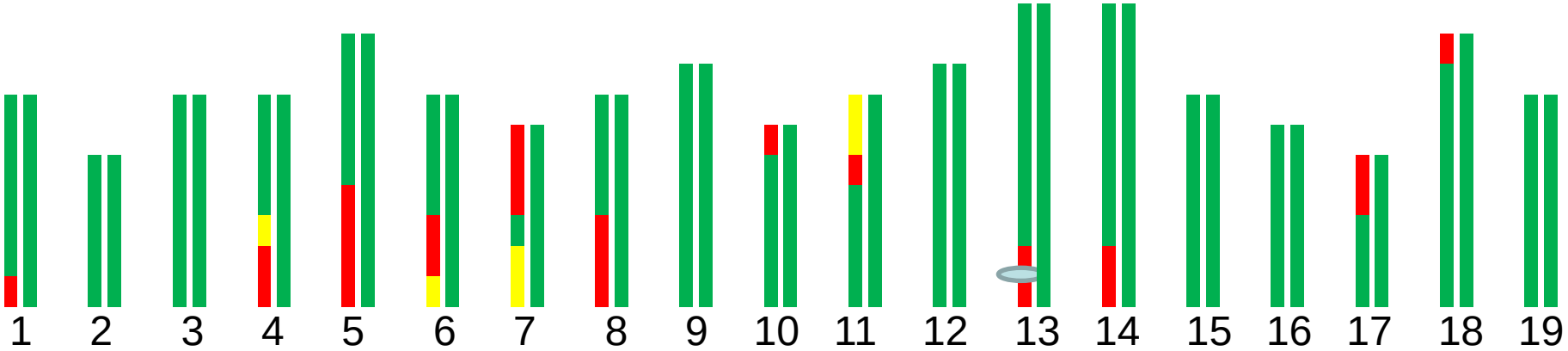
Introgression of phylloxera resistance in genepool of Vitis vinifera

Gf.V3125 (Trollinger x Riesling) x Börner

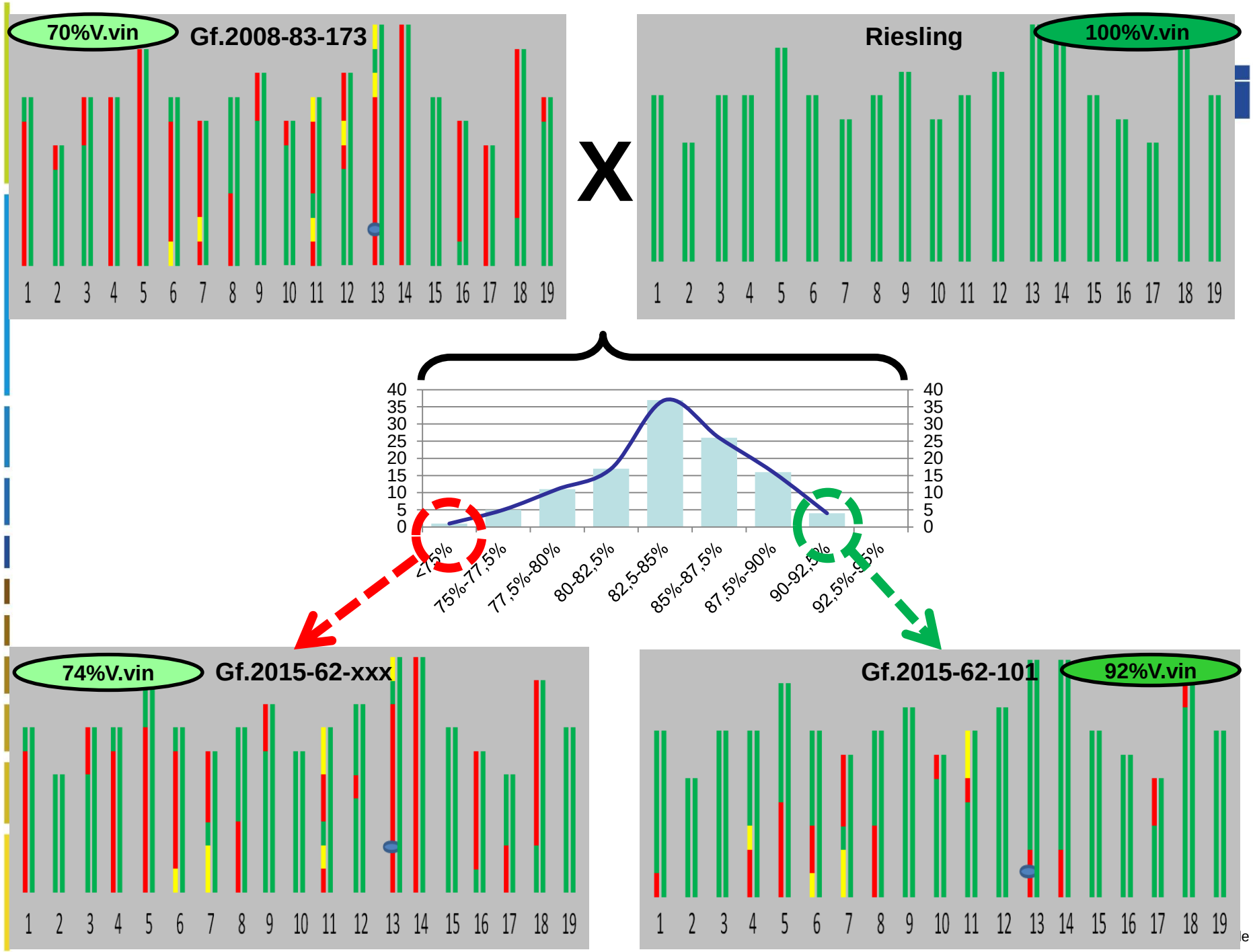
F_1-generation: Pinot blanc x Gf.1998-42-109

pBC_1-generation: Riesling x Gf.2008-83-173

pBC_2-generation: Gf.2015-62-101



green: Vinifera red: wild species Rdv1: locus for phylloxera resistance


70%V.vin
Gf.2008-83-173
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
X
Riesling
100%V.vin
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
40 35 30 25 20 15 10 5 0
<75%
75%-77,5%
77,5%-80%
80-82,5%
82,5-85%
85%-87,5%
87,5%-90%
90-92,5%
92,5%-95%
74%V.vin
Gf.2015-62-xxx
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Gf.2015-62-101
92%V.vin
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Topics:

1. Breeding for mildew resistance – stacking resistance genes

2. Introgressing phylloxera resistance

3. **High throughput phenotyping**

Motivation

<u>High-throughput phenotyping</u>

can be achieved through sensor-based data acquisition:

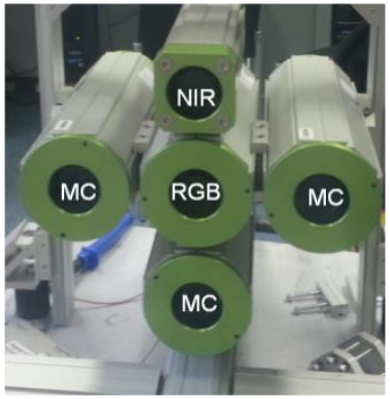
- automated image data acquisition (directly in the vineyard)
- automated data management
- automated data analysis

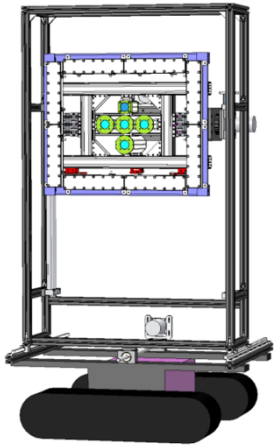
- objective and precise phenotypic data
- reduced error variation
- increased throughput
- **increased efficiency** of grapevine breeding

New breeding strategies/tools –

Automatic Phenotyping in the field:

- robotic platform & camera movement
- multi-camera-system & illumination
- geo-referenz of single vines (plant ID)

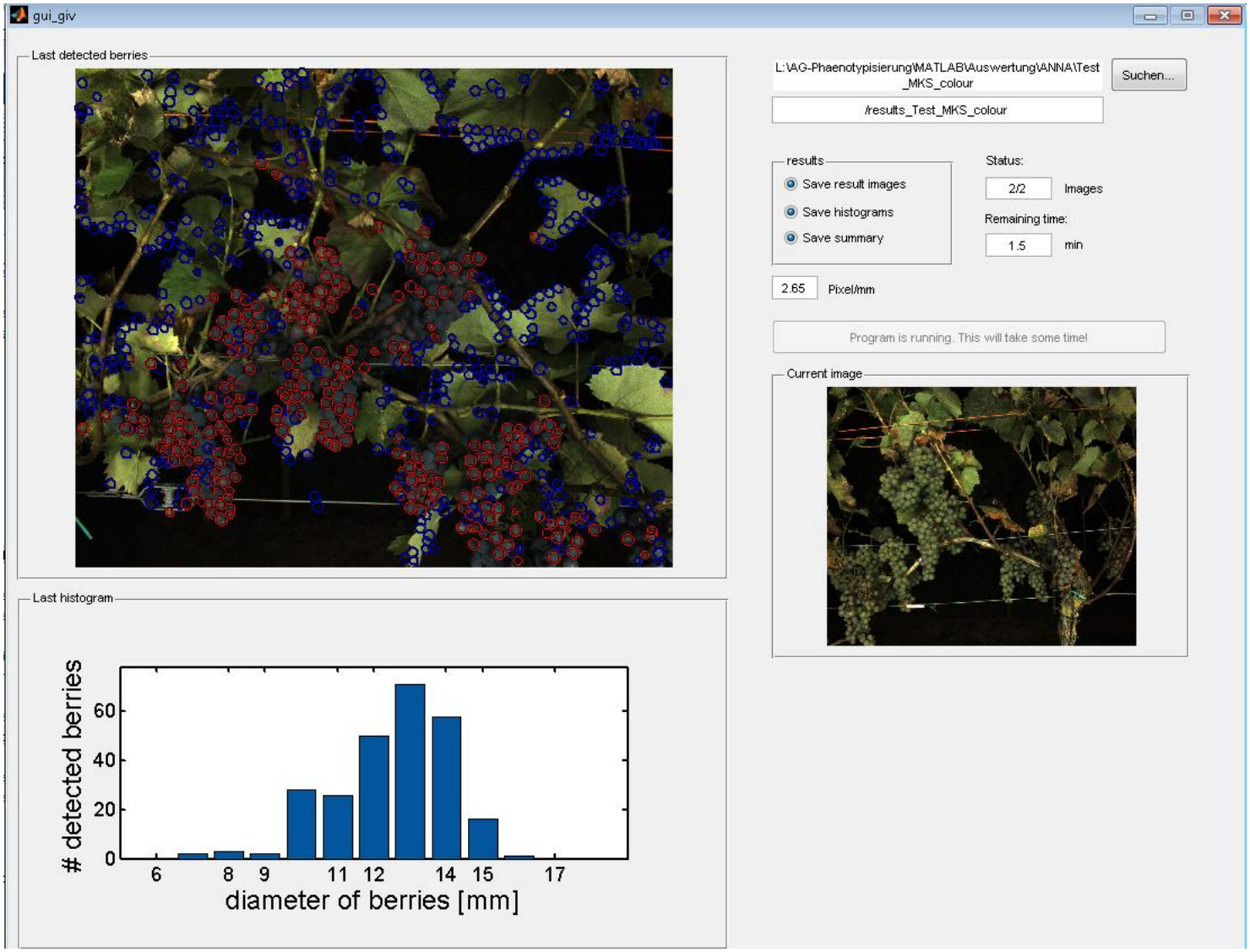




Kicherer *et al.* 2015a, Sensors

Hochschule Geisenheim University

New breeding strategies/tools – automatic data analysis - BIVcolor



New breeding strategies/tools – automatic phenotyping

Proof of concept: extracting trait information from RGB images

- Utilization of PHENObot and BIV_{color} in the genetic repository to evaluate
- 2700 vines (~970 Accessions) within 12 hours for
- berry size and -colour

Kicherer *et al.* 2015a, Sensors

Conclusions:

- Tremendous progress recently achieved in grapevine genetics will allow a paradigm shift from empirical breeding to knowledge based breeding. The routinely application of highly efficient molecular diagnosis tools will increase breeding efficiency substantially.
- This leads to:
  - acceleration of the breeding cycle
  - increased level of resistance
  - increased sustainability of resistance
- overall strategie: pyramiding several resistance sources - preferably with different resistance mechanisms - in combination with moderate plant protection measurements
- Breeding programs will address new challenges (further pests and diseases, phenologie, quality)
- Despite of some retarding elements the introduction of new cultivars derived from resistance breeding is progressing. Further stimulation can be expected by the introduction of further improved new cultivars in future.

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….. thank you for attention